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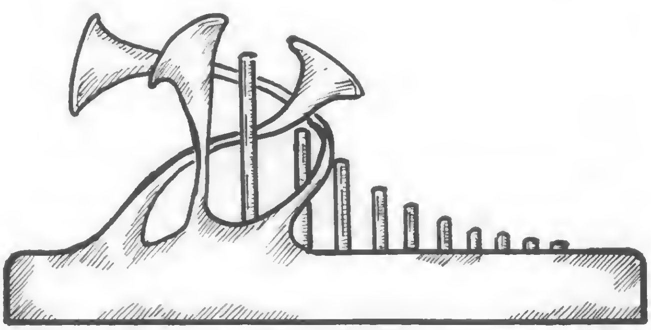
EXPERIMENTAL MUSICAL INSTRUMENTS

FOR THE DESIGN, CONSTRUCTION AND ENJOYMENT OF NEW SOUND SOURCES

There have been a couple of noteworthy responses to the article, "Slit Drums and Boos" which appeared in the last issue of EMI. The article considered the question of whether it is possible to create a tongue drum of many tongues tuned to a preordained scale. It concluded that, for reasons having to do with interference between tongues of different frequency on the same drum, it is not. But both Michael Thiele and Stephen Smith have checked in with evidence to the contrary. They report that they have had great success with tongue drums accurately tuned to a variety of scales. Thiele, in a telephone conversation, said that he is aware of some of the problems discussed in the article, and also that some tunings are more problematic than others. But, he said, through a number of techniques, a sympathetic feeling for the wood, and a strong dose of good instinct, he is able to produce finely-tuned drums of full, rich tone. Stephen Smith felt that the problems described in the article were greatly exaggerated, and gives his reasons in his letter appearing on page two.

On another subject -- we have often thought it would be a good idea occasionally to run articles in EMI on lesser-known traditional instruments which, for one reason or another, could be of special interest to new instruments people. In this issue, for the first time, we have such an article. It discusses an instrument with a most peculiar and thought-provoking sound-generating system, the Lesiba of southern Africa. Charles Adams has studied the Lesiba and its culture extensively, and is currently writing a book on the subject. His excellent article follows below.



IN THIS ISSUE

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WIND, BREATH AND STRINGS ROUND AND FLAT

By Charles R. Adams

Many of the current explorations into new musical instruments have the refreshing advantage of being unencumbered by histories and conventions. Some approaches have no known precedents while others have recovered the excitements of long-neglected techniques. Creative development of the full spectrum of acoustical and musical potentials which is evident in these activities, and to which EMI is so delightfully devoted, stimulates our imagination (or, rather, musement) and greatly enhances our musical sensibilities. Musical explorers are increasing our understanding and making it possible to listen with new ears to instruments which have enjoyed long histories of

(continued on page 3)

LETTERS

A couple of comments on the December issue (I,4). RE "Musical Instrument Classification Systems," some way of classifying instruments seems to occur in every society. One very informative study, outside of the more or less known 'classical' systems, is Hugo Zemp, 'Are'are classification of musical types and instruments, Ethnomusicology 22 (1):37-67. [Solomon Islands]. As you point out the wood-brass-string-percussion system arose with the European orchestral organization, but it was fairly closely related to ancient Greek and Roman uses:

Greek	Latin	
pneumaticon	inflatile	"wind"
enchordon	tensile	"string"
krousticon	pulsatile	"percussion"
organon	instrumentum	"instrument"

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And Sachs/Hornbostel's system seems closer to these than to the meanings of the ancient Indian system:

Sanskrit	
tata-yantra	"string"
cushira-yantra	"pierced, hollow"
ghana-yantra	"struck"
avanaddha-yantra	"tied-on, bound"

Ancient India and Greece have many close connections, however, which brings me to tuning systems also ancient. I have enclosed a list of references to the work of Ernest G. McClain, Emeritus Professor of Music, Brooklyn College, CUNY (now retired), an expert on ancient tuning systems. His works are quite technical and philosophical, but also very exciting and insightful, the best there is, I think, on Pythagorean number theory. Should you not want to cite all of the items, I would suggest at least some reference to The Pythagorean Plato which contains an appendix on the monochord, the great instrument of early theoretical organology.

Charles R. Adams

[The list of works by Ernest McClain follows.]

The Myth of Invariance: The Origin of the Gods, Mathematics and Music from the Rg Veda to Plato. New York: Nicolas Hays, 1976.

The Pythagorean Plato: Prelude to the Song Itself. New York: Nicolas Hays, 1978.

Chinese cyclic tunings in late antiquity. Ethnomusicology 23(2):205-224, 1979.

Meditations Through the Quran: Tonal Images in an Oral Culture. New York: Nicolas Hays, 1981.

Structure in the ancient wisdom literature: the holy mountain. Journal of Social and Biological Structures 5(3)233-248, 1982.

The bronze chime bells of the Marquis of Zeng: Babylonian biophysics in ancient China. Journal of Social and Biological Structures 8(2): 147-173, 1985.

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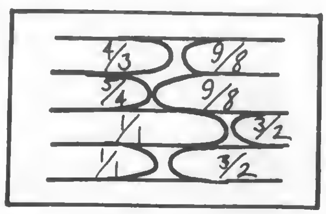
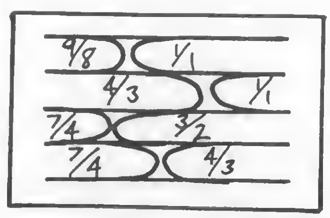
As I have been building tongue drums for some time now, I read with great interest the article on destructive communication [EMI vol. I #4]. However, my experience does not quite match up so I thought I'd share it with you.

I am always concerned with the tuning of each tongue drum I build and go so far as to use a strobe tuner (for speed and accuracy) and a justly intoned scale. It is only very seldom that I run into difficulty obtaining the exact pitches I am looking for. This is usually due to a peculiarity in the wood itself. A typical scale would go like this:



C D F G C D E G



F G B♭ C D F B♭ C

I was surprised to read that tuning one note effects the others. I could see this happening if one was elongating the slits to lower the notes but I have not been able to affect the tuning of the auxiliary while tuning a desired note. I make a point to remove wood only on the tongue itself as going beyond does effect other notes.

The hollow "thok" is in part due to the type of wood used, the lack of a tuned box or resonator for each note, and that the tongue is rigidly held. The "interference between the tongues" may be a cause also though I am not sure. I think it would have the same basic timbre if all the notes were tuned in fifths, octaves, or unisons.

An interesting correlation is drawn between tongue drums and steel drums though for the latter I think the problem is constructive communication. If you put a C next to a C# on a steel drum, both would sound when one was struck, causing undesirable conflict. Better to have adjacent notes in the harmonic series (as in the lead pan's cycle of 5ths pattern) or far away enough from adjacent notes to not bring them into play. The "double second" and "double tenor" pans both split their notes between two pans, have the same number of notes and are in the same range. Why do they sound so different from each other? One is a series of major thirds and tritones while the other is simply major seconds (two whole tone scales, one for each pan).

Lastly, no author was credited with the article. Does one assume the editor wrote it?

In good humor,

Stephen Smith

From the editor: Yes, one can assume the editor (that's me, Bart Hopkin) wrote it. In the first issue of EMI, when articles by other authors had not yet begun to materialize, I decided not to credit myself after each article because it would appear redundant. Perhaps out of habit, that policy has stayed in place since, though the original reasons for it no longer hold true.

The thinking that went into the slit drums article came from a series of explorations and experiments I did with tongue drums a couple of years ago, along with my experience with nail violins (mentioned in the article), and readings and conversations with people who had built some larger bowed rod instruments (see Tom Nunn's related comments on the Crustacean, EMI Vol. I #4, page 9). The problem described in the article -- interference between rigidly-connected vibrating bodies of differing frequencies -- is an important factor in many instruments, as your observations regarding steel drums confirm. But it's clear from your remarks and those of Michael Thiele (mentioned on p.1) that I went far too far too fast in stating that a fully tunable tongue drum was out of the question.

Discovering that I have put my foot in my mouth in a public forum isn't much fun. On the other hand, I have reason to celebrate: the dream of a well-tuned tongue drum has been saved from from oblivion. Thanks for your letter -- a fine example of constructive communication!

INSTRUMENTS

WIND, BREATH, AND STRINGS ROUND AND FLAT

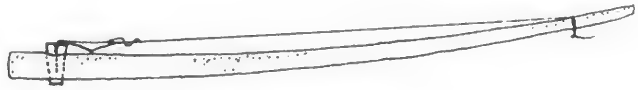
(continued from page 1)

conventional use -- perhaps to discover something new in the old, or, more generally, to arrive at a greater appreciation of the experimental qualities of traditional musical experiences.

Such were my thoughts on reading about Ron Konzak's (and friends') Puget Sound Wind Harp (PSWH) which utilizes flat strings to improve aeolian effectiveness, and the question of whether "there are other people working with or studying strings that are not round" (EMI I #3). For some time I have been interested in an air-activated zither played in Southern Africa, variously known as the **lesiba**, **gora**, **ugwala**, **makwindi**. In 1902, Henry Balfour (then Curator of the Pitt-Rivers Museum, Oxford) first noted that the instrument was similar to flat-stringed aeolian kite bows. Like the PSWH the **lesiba** exploits transverse and torsion wave acoustics by combining flat and round string principals. And there are other similarities between the two instruments. But unlike the PSWH a **lesiba** is a single-string zither (rather than a multi-string harp) whose vibrating cord is only partially flattened (with a special device, a quill), and it is breath (rather than wind) activated. The present form of the **lesiba**, a result of long and highly conventionalized musical experiences, may well be of some interest to those who are experimenting with wind, breath and strings round land flat.

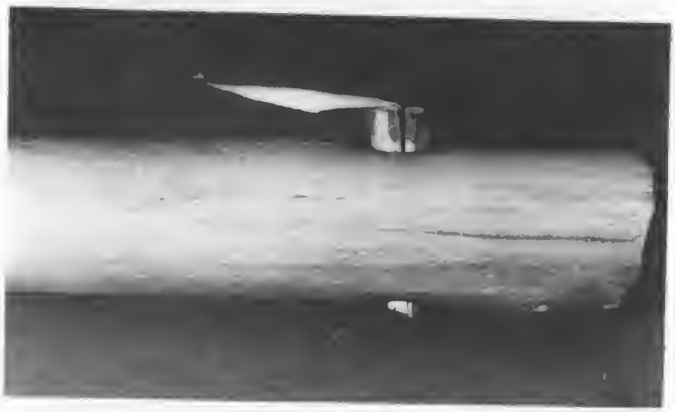
Little is known of the origin and early history of the **lesiba** except that it has been in use in southern Africa for nearly 400 years, a time span comparable to that of the modern form of the violin. It was first described about 1660 by a German student, Georg Friedrich Wrede, in use among the pastoral and nomadic Western Cape Khoikhoi. These were the people who had exchanged musical greetings with Vasco da Gama in 1497, they with flute ensembles and dancing and the Portuguese with trumpets and jigs. The instrument has since been part of the sound resources of most of the indigenous southern African peoples (Xhosa, Zulu, Venda, Sotho, Tswana, Peli, San). A century ago it was regarded as "...the instrument which is, par excellence, the characteristic instrument of Southern Africa..." (John G. Wood, The Natural History of Man, 1874). And it continues to be a major musical tradition, most especially for herdsmen in the independent Kingdom of Lesotho. The late Percival R. Kirby (Emeritus Professor of Music, University of the Witwatersrand, Johannesburg) made extensive studies of the instrument and its history.

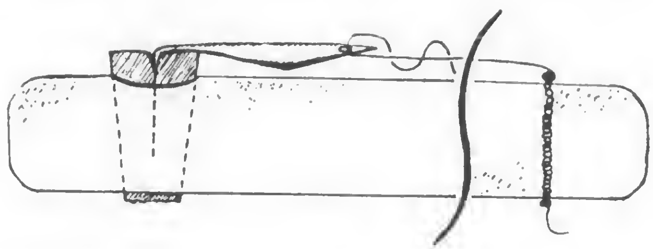
In sound and structure a **lesiba** seems to be an amalgamation of flute playing techniques, mouth-resonated musical bows, bullroarers, jews-harps, flat-stringed aeolian instruments, and voice disguisers. The instrument is constructed with a round, slightly curved and tapered, rigid wooden stick (about 2.5 cm x 1 m). A fine wire or sinew is attached to the narrower end of the stick with



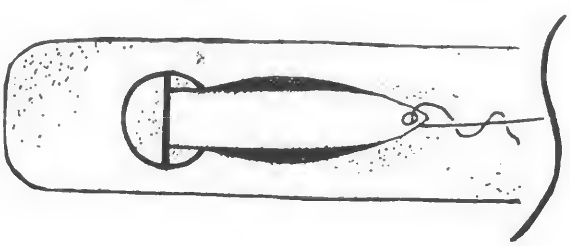
LESIBA. Drawing by Hester Simpson.

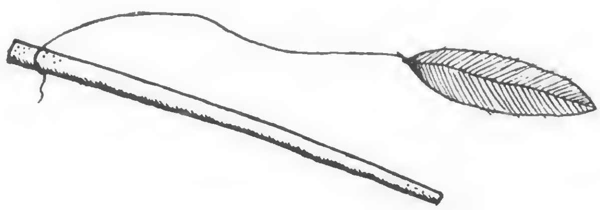
ABOVE: THE TENSIONING LOOP-BRIDGE. BELOW: THE QUILL AND PEG. Photos by Charles Adams.





ABOVE AND BELOW LEFT: DETAILS OF THE QUILL AND STRING ATTACHMENTS AND THE TENSIONING LOOP/BRIDGE. BELOW RIGHT: BULLROARER. Drawings by Hester Simpson.





a braided cord which serves both as a bridge and as a tensioning loop. The other end of the string is fixed to a leaf-shaped piece of quill, which itself is attached to the larger end of the stick by a split peg in a hole.

A lesiba's configuration of stick, string and quill is reminiscent of some modern southern African bullroarers which have stick handles and use large, heavy feathers for the blade of the instrument. The two instruments are also acoustically similar insofar as both employ an air-activated blade (quill) in combination with a tensioned string for sound production. Bullroarers, like other aeolian instruments (cf. Gordon Monahan's "The Music of Aeolian Harps" 1985), have often been regarded as signs or personifications of environmental phenomena -- wind, rain, thunder, lightning -- forces which affect people's lives and which they seek to understand and influence. A **lesiba**'s structural components, and their related sonic properties, made from parts of the environment (cattle sinew, bird feather quills, tree branches) are, in Monahan's phrase "...structures which interact with nature....forms integral with the very vibrations they articulate...." A lesiba's components are symbolic of the 'vibrations' of the social, as well as the physical, environment of the individual performer -- cattle exchanges represent marriage, children and social reciprocity (one Sotho term for a lesiba's string, lesika, means 'genealogy'); the trees which provide the wood for the stick represent the power and authority of chiefs and the community at large; the quills are 'birds,' symbols of the mystical forces of life and death, growth and decay, as are the feathered bullroarers which are "voices of gods." A **lesiba** as a whole models the multiple circumstances of the individual self, the physical, social and spiritual environments. A lesiba is the means by which these become manifest in sound and thereby make sense. For **lesiba** players soundmaking in general definitely aspires to John Blacking's ideal of "soundly organized humanity through humanly organized sound" (cf. How Musical is Man?, 1973). Indeed a common everyday Sotho greeting, similar to 'how are you?,'translates quite accurately as 'how are you resonating /resounding/reverberating in your environment?'

The string of a **lesiba** is tuned, to individual preference, by adjusting the tension loop to a fundamental in the range of 50 to 100Hz; this is very nearly inaudible considering the small diameter and low tension of the strings used, and is not sounded in performances. The player of the instrument forms an air duct around the quill with

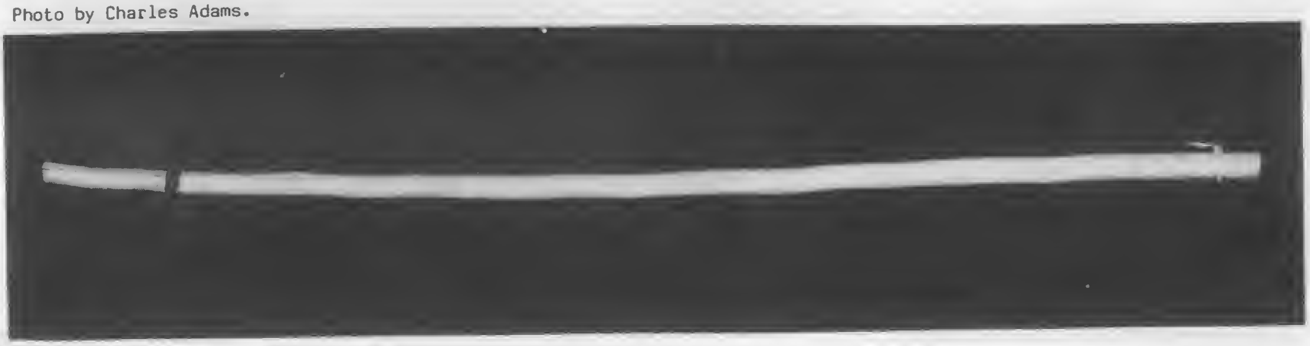
DEMONSTRATION OF PLAYING POSITION (RIGHT) AND TECHNIQUE (BELOW) BY SITWELL MPHALENG RAKHORO

his lips and hands (the photo shows a common playing position), and sets the quill in motion by strong breathing, inhaling and exhaling. The quill is, in effect, a flattened portion of the string specifically designed to vibrate in an air-stream much like ribbon-reed aerophones and, in fact, the lamellae of jews-harps, which are also aerophones (cf. Crane 1968) and sometimes even air-activated. The **lesiba**'s quill is a mechanical transducer of breath forces to the string. And by varying the air speed a player can energize the string to vibrate in the range of the 5th to the 15th harmonic partials of its fundamental. Different frequencies of the vibrating string are principally determined by air speed across the quill. A player also selectively reinforces them by varying the volume of his mouth cavity, a technique like that of mouth-resonated musical bows, some of which are found in southern Africa also with flattened strings. But musical bows sounded by plucking, striking or bowing depend on mouth resonance as the only way to select particular overtones from among the many produced by the string. With the lesiba, by contrast, the string itself vibrates predominantly in the overtone selected by the air speed over the quill, while the mouth resonance enhances the selection but is not required.

The quill of a **lesiba** moves in the airstream with three kinds of acoustically significant patterns, all of which sound by themselves as well as effect the motion of the string: torsional wave sounds from the partial twisting of the quill ( ), edge turbulence ( ) or vortex sounds, and those which come from a 'valving' action of the quill as it alternately opens and closes off the airstream. This last motion is the principal one which generates transverse waves in the string. Compared to the relatively 'pure' string tones, the torsion and turbulence sounds of the quill are 'grainy.' Performers can vary the proportions of quill and string sound combinations in the overall sonic textures from, in their terms, 'coarse' sounds, emphasizing quill acoustics of indeterminate frequencies, to predominantly 'smooth' sounds, emphasizing the aeolian-like harmonics of the string. When ending performances players inhale abruptly on the quill and produce a raucous shriek they call 'flash, lightning, bright.'

Compounding the problems of acoustical description a bit further, lesiba players also vocalize continuously while inhaling and exhaling on the quill. Melodic vocal lines are counterposed in parallel and contrary motion with those developed from the string harmonics, a technique also used in some southern African flute playing. Players strive to sustain a continuous polyphony of string and voice in an ever-changing textural sound stream, irrespective of changes in breath direction. A favorite, and physiologically difficult, procedure combines low vocal pitches (requiring relaxed vocal chord tension) with high string harmonics (requiring high diaphragm tension and fast breath speed). Another musical and esthetic objective is to achieve a blend or cohesion of string and voice sounds such that their distinct differences are not readily hearable. When done

LESIBA. Photo by Charles Adams.



well the overall sound is that of timbrally modified singing, a voice disguised by the acoustics of string and quill. Another overall characteristic of a lesiba's sound, also heard in aeolian instruments, is that of a 'reversal' of the attack-decay conventions. As string and voice pitches change melodically, and breath flows in and out, tonal attacks are gentle then increasing in intensity and clarity. Play a violin sonata tape backwards to get the idea.

The songs which are composed and played on a **lesiba** are uniquely called 'birds' (in Sotho, linong) and are considered to be expressions of the mystical forces which permeate all things, the life of the performer and all aspects of his environment -- cattle, plants, birds, etc. Hence the musical continuity and cohesion of stick-string-quill (the **lesiba**) and voice express an interpenetration and unification of self and circumstance, of player and instrument. **Lesiba** performers contend that it is by means of this esthetic 'communion' that communication and community are possible. Every man in Sotho society is expected "to acquit themselves well on the **lesiba**" (Huskisson 1982) and those who do not are often "contemptuously esteemed" (Mokhali 1967). Expectations of musical expertise hold true for women as well, though in respect to different instruments.

Four major performance situations exemplify the 'musicated' life-style: (1) communication with cattle while herding, where cattle are given instructions and form the audience -- "whenever they hear him play (they easily recognize his mode of playing and distinguish him form other performers), they exhibit their appreciation of the music by clustering and huddling around him" (Mokhali 1967); (2) social/musical competitions between performers which emphasize skill and technique and the sharing of repertory; (3) times when master players patiently teach younger ones techniques, styles and uses of the instrument, and (4), occasions where a player plays to, for, and by himself just to muse and meditate (or to practice). With further analogy to the PSWH, a **lesiba** is "conducive to communal enjoyment, at the same time rewarding in solitude." (EMI I #3).

Needless to say, the **lesiba** has presented some difficult problems in organological classification. Throughout the 19th century it was regarded simply as a 'curiosity;' for most of this century it has been an ambiguity, a 'stringed-wind' musical instrument (e.g., Balfour, Kirby). Other observers have come up with quaintly descriptive terms, such as **Federkielbogen** (feather-wedge bow). More recent systems of description and classification, those which recognize the multidimensionality of instruments, are less problematic than, say, the von Hornbostel-Sachs conventions (see EMI #4). For the Sotho who play the instrument there are no confusions at all. They classify instruments according to the parts of the body which are used to activate them, for example, "instruments played with the mouth" (**ka molomo**) which includes the **lesiba**, and "instruments played with the hands" (**ka matsoho**). Instruments are regarded as extensions of people in all their aspects; people, not instruments alone, make music. So while a **lesiba** is not exactly a wind harp, we can call it a breath zither, or even better, recognize that it belongs to what John Greenway (1976) once called "the genus of somatophones, for which the instrument is the human body" and its circumstances.

Players of the **lesiba** talk a lot about music being inside the person, more than in the sounds or in the instrument. While the PSWH is an instrument that "people can get inside of," a **lesiba** is an instrument that "can get inside of people." Of the PSWH, EMI nicely said, "one can't help but gain a new sense of the personality of the wind as it plays on the strings with, in Konzak's words, 'drama, capriciousness and humor.'" When listening to the music of the lesiba, I can't help but gain a new sense of the personality of the performer as he breathes on the quill and sings with the string. And one can't help but hope for another 400 years of all these aeolian delights.

An extensive ethnomusicological monograph on the lesiba (including numerous photographs, illustrations, recordings) will be forthcoming shortly. In the interim anyone with comments or questions are welcome to contact the author at 110 Post Ave. #509, New York, NY 10034; phone: (212) 304-8746.

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ORGANIZATIONS AND PERIODICALS

THE INTERVAL FOUNDATION

People interested in new musical instruments should know about the Interval Foundation and its publication, Interval: Exploring the Sonic Spectrum. Interval is the only periodical other than Experimental Musical Instruments which features new acoustic and electro-acoustic instruments on a regular, rather than an incidental, basis. The organization is not exclusively concerned with instruments, though. Here is how it describes itself:

> Interval Foundation, a charitable, nonprofit corporation, benefits those individuals and organizations that are working with expanded musical materials (scales and instruments especially), and integrated art forms.
>
> Interval/Exploring the Sonic Spectrum, sponsored by Interval Foundation, is a quarterly publication growing out of the flowering of creative activity in the microtonal field. In the years since the death of the leading pioneer, Harry Partch, a variety of new instruments, scales and compositions has been created. Interval is a forum for ideas, a showcase for new hardware and most importantly a vehicle for communication bringing artists together in a common cause.

Interval magazine was founded in 1978 by Jonathan Glasier. Glasier dedicated his new magazine to the memory of Harry Partch, then dead four years. Glasier knew Partch's work well, for Partch lived with the Glasier family for a year or so when the editor-to-be was a child, and they worked together musically in later years as well. On the relationship of the Partch legacy to current work, Glasier says, "Because he detested the "guruship" of the master/student hierarchy, there is no Partch cult, except in the minds of a few." Accordingly, the magazine has not attempted to follow Partch's worldview slavishly. Discussions of some aspect of Partch's work appear somewhere in most issues, but the intention has been to work with new material in his spirit while avoiding the development of a Partchian dogma.

As with Partch's work, the magazine's first concern has always been with intonational systems, and the creation of alternatives to 12-tone equal temperament. Over the years, perhaps something over half of the articles have been discussions, sometimes quite technical, of intervals and scale systems. But, again as with Partch's work, Interval's interest in new tuning systems leads to a search for instruments capable of playing in new systems, and accordingly to an interest in new instrumental resources. The magazine's record on this score has been very strong all along: the list of builders whose work has appeared in these pages over the years is both long and illustrious. While Interval has touched on a great deal of instrument building activity, however, its descriptions of instruments usually are not explicit or detailed.

Interval Foundation came into being shortly after the magazine's inception, in 1979. The idea behind the foundation was to pursue the aims of the magazine in other arenas, including concerts, workshops, research, and the like. Among the foundation's activities have been several Exhibition/Festivals of New Instrumental Resources, taking place at the Center for Music Experiment at the University of California at San Diego and, more recently at UC Santa Cruz. Each Exhibition/Festival has included exhibits of new instruments and sound sculptures, lectures by builders and theorists, and panel discussions on aspects of microtonality and new music. A dual catalog for the 1979 and 1980 festivals is bound into the Spring-Summer 1980 issue of Interval.

In the past, Interval Magazine was published at irregular intervals. Subscriptions were sold by the volume, with four issues comprising one volume. The most recent issue, Spring-Summer 1985, completed volume IV, and the word now is that there will be a format change beginning with volume V. The magazine, with the new subtitle Journal of Music Research and Development, will adhere to a quarterly publication schedule, with larger issues appearing in spring and fall, and smaller, newsletter-style issues appearing summer and winter.

Subscriptions to Interval in its new format are $18/year. All back issues remain available (some in photocopy only) for $3 apiece. The address is:

Interval
Journal of Music Research and Development
P.O. Box 8027
San Diego, CA 92102

INTERVAL FOUNDATION'S CONFERENCE OF INTERVALIC MUSIC

The Interval Foundation is sponsoring a gathering of people working with microtonal music and new instruments, set to take place July 12-19 of this year. The location will be Cuernavaca, Mexico, about fifty miles southwest of Mexico City. There will be workshops during the day and concerts each evening. All events will be presented bilingually. Some of the plans include a visit to Tepostlan, a natural valley possessing extraordinary acoustic properties and a resident commune that builds a unusual new and traditional instruments; a trip to Mexico City to hear the pianos of Mexican microtonal composer Julian Carillo, each tuned to one of the equal temperaments up to sixteen divisions per octave; and opportunities to hear a number of other unconventional and microtonal instruments.

Events of this sort are a rarity in the world of new instruments, and the plans for this one suggest that it could be both a very valuable experience and lots of fun.

For more information, write or call:

Interval Foundation
4195 Norfolk Ter.
San Diego, CA 92116
(619) 284-2473

INSTRUMENTS

DISORDERLY TUMBLING FORTH

Designed and built by Bart Hopkin

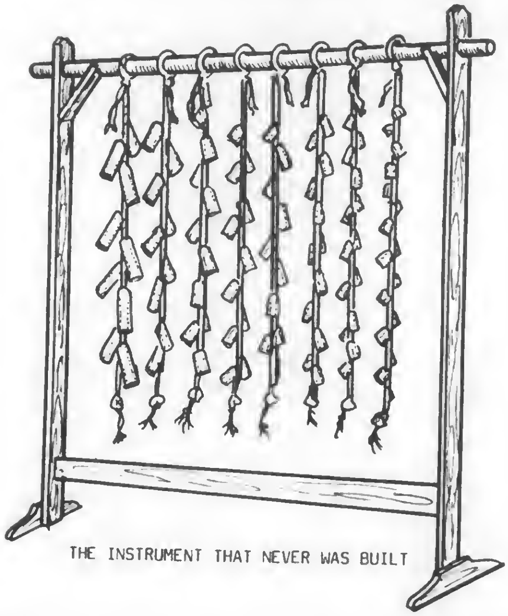
Here's an indulgence. The editor of Experimental Musical Instruments is going to write an article on one of his own instruments. The instrument is the Disorderly Tumbling Forth, a tuned idiophone played by means of a keyboard.

Most of my ideas for new instruments proceed from some accidental encounter in the material world. I happen upon a sound by chance or mishap; I decide that I like the sound and that it has potential, and I begin to look for ways to bring out that potential. The Disorderly Tumbling Forth was not like that. Its beginnings were in a purely mental event: I began to hear a sound in my head that I had not heard in the world. I wanted to bring the sound out into the world somehow, and, to make matters more imperative, I found myself writing music for it.

It will be difficult to convey the quality of my mental sound, but I can describe the basic idea. The sound I heard was sustainable, continuing without decay as long as the player chooses to sustain it, as with a bowed instrument or wind instrument. It was not truly continuous though, but made up of a thousand little sounds of more or less rapid decay, creating the effect of continuity and sustainability by their multitude. The feeling was not that of a tremelo; rather, the individual tones tumbled out over one another in such confused profusion that their individual identity and rhythm were lost in a glittering stream of sound.

Thinking about means for realizing the sound, I quickly focused on the idea of groupings of metal sounding objects of some sort, bells or chimes or rods or such. All of the objects within one grouping could be tuned to the same note, and all subjected to some kind of continuous agitation to make them clang around together producing a dense, random, continuing splash of sound. One set of clangers could serve for one pitch; a set of sets could be tuned to some scale or other. I kept returning to the image of the doorbell that hung for years at the back door of the house in which I grew up. It was a set of several bells tied along the length of a cord hanging from a screw in the wall; visitors would shake the cord and the bells would all jangle in their unpredictable way. That sound, though not tuned to a single pitch, was not too far from what I was after.

For a long time the instrument was to be a series of ropes suspended from a horizontal bar, each rope having ten or so chimes on it tuned to one pitch. The player would stand before it, grasping the ends of the ropes for the desired pitches and shaking them for as long as each note was to last.



THE INSTRUMENT THAT NEVER WAS BUILT

I feel some nostalgic affection for that idea now. It would have been picturesque, and would have had the quality, which I admire, of being completely readable; of being just what it appeared to be, different and new and simple. Perhaps someone reading this will see fit to build one -- that would make me happy. In the end I decided not to build one myself, for I began to feel that the method of playing was too awkward. The ropes and chimes would swing around, they would bonk each other at unwanted times, the player would grab at them and miss, the whole thing would be too sloppy for playing in rhythm.

It is easy to see why mankind invented keyboards. When you begin to think about simplifying the playing action of an instrument by mechanical means, a set of levers controlling the sounding devices is a very practical way to go. It took me a while to come around to it, but eventually I found myself designing keyboard actions for the instrument I had in mind.

The ropes were replaced by rigid frameworks of very simple design in which the chimes were to hang. By agitating these frameworks somehow, the chimes could be made to strike each other in a recurring, random fashion like windchimes. I decided to use copper tubing for the chimes, because of their pleasant sound, ready availability and low cost.

My first keyboard action designs were absurdly complex. They had continuously-operating mechanical agitators controlled either by an electric motor or by weaving-loom style pedal spindles. Pressing a key would somehow bring the framework supporting the chimes into contact with this agitator for as long as the key was depressed. Ridiculous. I eventually realized that with a reasonably large number of individual chimes for each note it would be easy to agitate the chimes by hand with a tremelo action on the key. Even a slow tremelo, acting on eight or ten chimes, would produce the kind of continuous tumble of sound that I was after. It would also make the instrument simpler to build and maintain and more responsive to the player's touch.

Without too much more misdirected effort I managed to come up with a workable design, later to be followed by a second edition with improvements. The two designs have since been built and are now functioning instruments -- I play them all the time.

The first version is a furniture-sized affair, standing on the floor like a small harmonium. The chimes are set in wooden frames located in the chamber under the keyboard. The frames stand on one leg and can tilt vertically. Each frame is attached by means of a length of nylon cord to the back end of its corresponding key. When the key is depressed and its far end rises, the cord tilts the frame, giving the chimes a shake. When the key is released both the key and frame fall back into place by gravity.

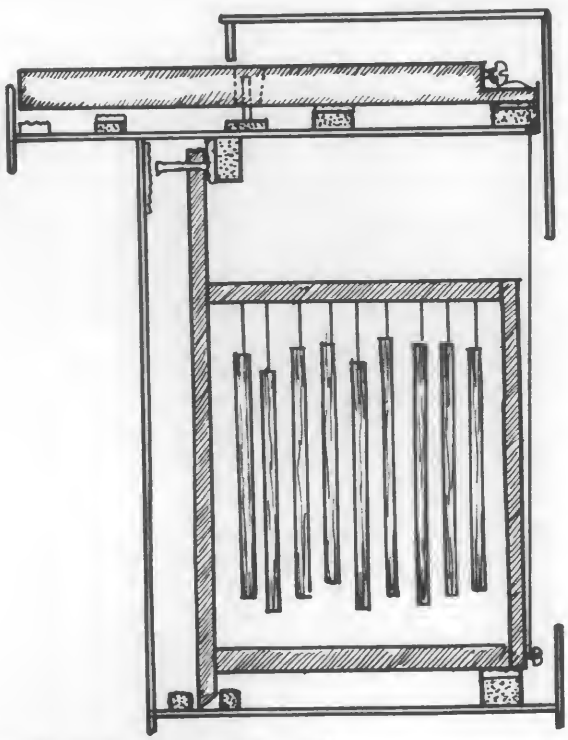
This design owes much of its form to the need to overcome an awkward problem: the standard copper tubing that is available at most hardware stores has an outside diameter of 5/8ths of an inch. For the tube to vibrate freely it needs a touch more space than that. But the lateral space allotted for each key of a standard keyboard (the total space divided by the number of keys) is just a smidgeon over a half inch. This means that the frames and tubes won't fit in a simple arrangement directly behind the keys. The chimes will probably have to be spread out over an area wider than the keyboard, and the impulse of a key's movement when it is played may have to be displaced laterally in order to reach the proper chimes. The strings connecting the keys and the frames on this first edition of the Disorderly Tumbling Forth allow for this displacement, since they can work at a slight angle.

This action has the disadvantage that the response is slow; the slight stretchiness in the nylon cord and the swing time of the tubes before they begin striking one another contribute to a noticeable delay between the touching of the key and the sounding of the note. It also has the disconcerting habit of producing a fairly loud tone when the key is released. The 5/8 inch tubes do have a pleasant sound, though.

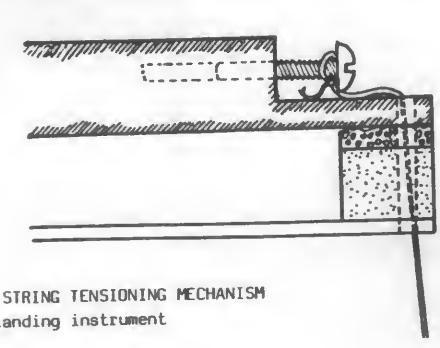
I was able to develop a far simpler and more responsive action when I managed to get hold of some narrower copper tubes. It turns out that 3/8 inch O.D. rigid copper tubing is sometimes used in commercial refrigeration, as in the frozen foods section in a grocery store. (A soft alloy copper narrow-diameter tubing, sold in flexible coils, is more readily available, but it is not effective acoustically.) I found the narrow rigid tubing at an industrial outlet dealing primarily in plumbing supplies. The narrower tubing allowed me to place the framework and the tubes for each note in a line directly behind each key. This made it possible to make a single rigid assembly of the key and the frame. The assembly rests on a fulcrum, so that depressing the key shakes the frame in the most direct way possible.

The completed narrow-tube instrument is more compact. It sits on a table top like a virginal. The tone is a little edgier than the larger in-

THE ORIGINAL, LARGER VERSION OF THE DISORDERLY TUMBLING FORTH



THE ACTION OF THE FREE-STANDING INSTRUMENT



DETAIL OF THE STRING TENSIONING MECHANISM
of the free-standing instrument

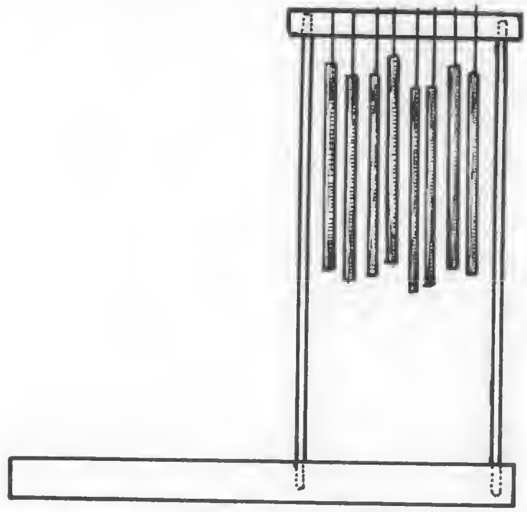
strument, but the action is faster, easier and quieter.

Making a Disorderly Tumbling Forth requires terrific patience. My tabletop model has a range of two octaves and a fourth, with eight tubes per key. That makes two hundred and forty copper tubes which must be individually cut, tuned, drilled and hung. Due either to irregularities in the alloy or slight variations in diameter or wall thickness, they cannot be tuned by means of a formula -- if G is six and a half inches for one tube, it might be six and three eighths for another. Each one must individually go through the slow process of cutting, testing, cutting or grinding some more and then testing again, and again, and again, to be brought in line. This process calls for a tubing cutter, which makes quick, neat cuts. The tubing cutter cannot remove amounts of less than about 3/16th of an inch though, so the old hack saw comes into play. An electric grinder makes the fine tuning easier, and an electronic tuner is always a good friend. It makes sense to start with the lowest note and work one's way up, so that tubes accidentally cut too short -- a frequent and inevitable exasperation -- can be set aside and used later for a shorter/higher note.

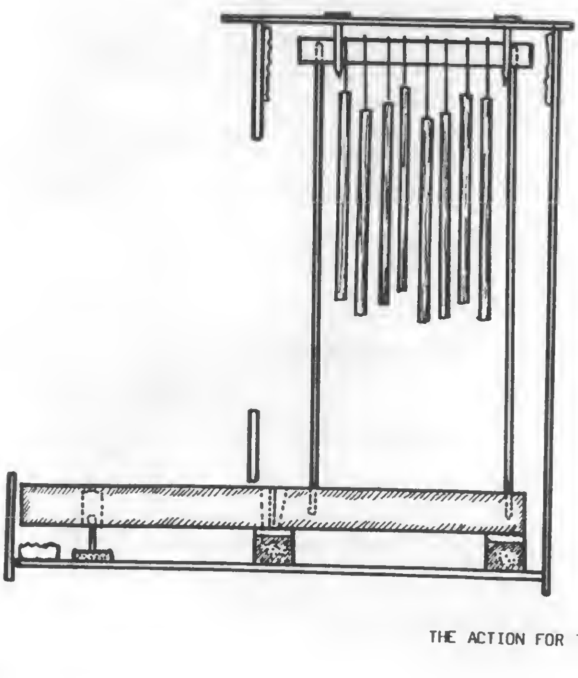
The tubes can be suspended in their frames by any means that seems convenient. The important thing to keep in mind in devising a suspension system is to keep it simple, for whatever the process is, it will have to be repeated 240 times. If it involves running a nylon cord through two holes, that makes 480 holes to drill, 240 snippets of cord to cut, 480 times the snippets must be threaded through the holes, 240 knots to tie in the snippets, and so on.

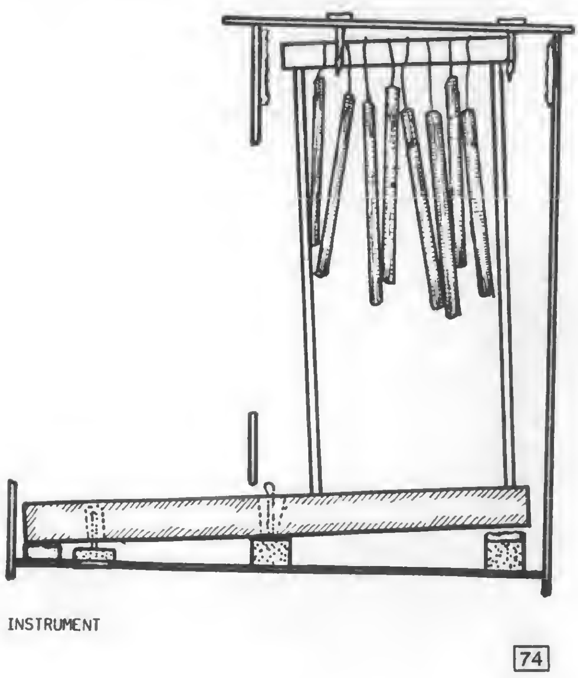
The tubes for any one key-and-framework assembly will clang against the tubes for the adjacent ones if they are not prevented from doing so. To stop the F# tubes from striking the F natural and

THE TABLE-TOP MODEL OF THE DISORDERLY TUMBLING FORTH



ONE KEY AND FRAMEWORK for the table-top instrument

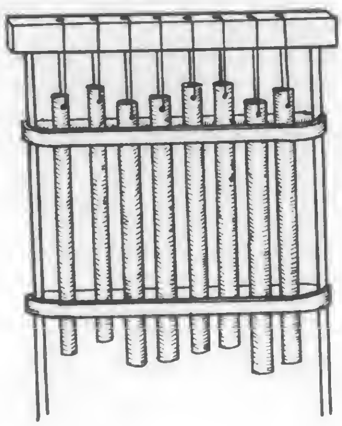




THE ACTION FOR THE TABLE-TOP INSTRUMENT

the G natural tubes whenever F# is played, the larger Disorderly Tumbling Forth uses a piece of cloth stretched firmly over one side of the wooden frame and tacked in place, providing a silent barrier between each set of tubes. The tabletop model has no wood to tack into, but I found that the following unlikely system works well: two rubber bands are stretched around the tubes, holding them in place.

THE SUSPENSION OF THE COPPER TUBES



They damp the first and last tubes somewhat and may damp the in-between ones a bit as well, but in the cumulative effect this is scarcely noticeable. Within the confines of the rubber bands the tubes are still free to swing and shake and resonate nicely.

The range of the tabletop Disorderly Tumbling Forth is from G below middle C, using tubes of about nine inches, to the C two octaves above with tubes of four inches or so. This range was determined by the properties of the tubes. They produce an overtone an eleventh above the fundamental which becomes more prominent as one descends in pitch. Toward the bottom of the instrument's range the overtone becomes very distracting, and were the range to extend further down it would come to dominate the intended pitch entirely. At the opposite extreme, the copper tubes simply won't produce pitches much higher than that top C.

For the larger instrument I made the keys myself. It was a lot of work, but they work fine and they look pretty, with the naturals stained dark and the sharps and flats left light in color. They have what I regard as an appealingly sloppy look, since nothing I make ever comes out square. For the keys for the table-top model I raided a dead piano. Piano keys often have a bend just beyond the playing surface of the key to align the far end of the key with the correct hammer action. I had to eliminate the bend in the keys I used by cutting off the back part of the key just short of the angle and re-aligning it.

It is amazing that piano actions, in all their complexity, can be made as quiet and smooth as they are. I tip my hat to the manufacturers. Even with the very simple action for the Disorderly Tumbling Forth described here, I have found that reducing noise and friction is a real challenge. Spraying all moving parts with a silicon spray lubricant (available at hardware stores) helps. The answer really lies, however, in making the parts as straight and true as possible, within fine tolerances and close alignments. This is second nature to a good craftsman; for me, unfortunately, it scarcely rates as third or fourth.

The design of the body of the instruments, the housings in which the innards sit, is primarily a matter of convenience and common sense. But this is the part of the instrument that will be seen, so one should also take aesthetic considerations into account at this stage. My designs can be seen in the photographs.

Having described how the keyboard chimes are put together, I now address the question, do they succeed in realizing the sound I originally heard in my imagination?

I think they come pretty close. A tremelo on the key produces something much like the gilt-edged stream of sound, the refined version of the bells at the back door, that I wanted. When the agitation of the key ceases, the glitter stops but the ringing of the tubes remains to die away slowly. A single stroke of the key -- something I didn't think about much when I was designing the instrument -- produces a brief, dancing cluster of sound, again followed by the residual ringing.

A thought worth entertaining here is, what other materials besides copper tubing would produce a larger range or sweeter tone, or would be easier to tune? People who have worked a lot with windchimes will probably have something to say about this.

NOTICES

CALCULATING FREQUENCIES FOR EQUAL TEMPERED SCALES

In the following article, Christopher Banta provides the basic mathematics necessary for finding the frequencies for the pitches of equal tempered scales.

The overwhelmingly predominant scale system currently used in Western music is twelve-tone equal temperament. In 12-equal, we divide the distance between any two notes that are an octave apart into twelve equal steps. To make sense of that statement, though, we have to define 'equal.'

As a general rule, the human ear seems to hear equal increments in pitch when the frequency of each succeeding pitch in a series (i.e., a scale) is equal to the frequency of the preceding pitch multiplied by a constant:

F1 x C = F2; F2 x C = F3, and so forth.

This is a psycho-acoustic fact more than it is a purely mathematical one, and there are exceptions and ambiguous cases -- but it nonetheless serves as the basis for our mathematical calculations in generating scale systems.

If we are to have twelve equal scale steps to the octave, the constant described above must be such that when it is applied twelve times in succession the final pitch is indeed an octave above the starting pitch. The ear hears two pitches as being an octave apart when the frequency of the higher is twice that of the lower; thus the twelve applications of the constant must have the effect of doubling the frequency of the starting pitch:

F1 x C = F2; F2 x C = F3.....F12 x C = 2(F1)

In his article, starting below, Chris Banta shows how to find and apply this constant, first for twelve equal, and then for more exotic equal temperaments. In a coming article slated for one of the future issues, Banta will cover conversion of frequency to cents (cents is the logarithmic unit for fine pitch measurement widely used on tuning devices and in writings on intonational systems).

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SCALES AND THEIR MATHEMATICAL FACTORS

By Christopher Banta

The twelve tone scale used in Western music is based on a mathematical factor. When properly applied this factor will yield an equal tempered scale of twelve notes to the octave. These twelve notes, having been systematically laid out, are used on the piano keyboard and on the guitar fingerboard, as well as other on instruments.

THE FACTOR

The factor can be determined by finding the 12th root of two, which is expressed as $\sqrt[12]{2}$ What this equation says is, "What times itself twelve times equals two?"

$$\sqrt[12]{2} = 1.0594631$$

This calculation can be performed on a scientific calculator with a $\sqrt[x]{y}$ function key.

[1] [$\sqrt[x]{y}$] [1] [2] [=] 1.059631

$$\sqrt[12]{2}$$

The RADICAL corresponds to the number of notes per octave.

The RADICAND refers to the magnitude of a quantity, in this case the halving or doubling of frequency from octave to octave.

For example: Middle C vibrates 261.63 times in one second (Hz). Doubling it would cause it to vibrate at 523.25Hz, which is C an octave above. Halving middle C would bring it down to 130.8 Hz -- one octave below.

If we take the number "1" and multiply it by the factor (1.0594631) we have a total of 1.0594631. Multiply that result by the factor again and we get 1.122462. When we repeat the process twelve times we arrive at two.

(1)	1.0000000 x 1.0594631 = 1.0594631	(2)
	1.0594631 x 1.0594631 = 1.122462	(3)
	1.122462 x 1.0594631 = 1.1892071	(4)
	1.1892071 x 1.0594631 = 1.2599209	(5)
	1.2599209 x 1.0594631 = 1.3348397	(6)
	1.3348397 x 1.0594631 = 1.4142134	(7)
	1.4142134 x 1.0594631 = 1.4983069	(8)
	1.4983069 x 1.0594631 = 1.5874008	(9)
	1.5874008 x 1.0594631 = 1.6817925	(10)
	1.6817925 x 1.0594631 = 1.7817974	(11)
	1.7817974 x 1.0594631 = 1.8877481	(12)
	1.8877481 x 1.0594631 = 2.0000000	(1)

By doing this we have created a geometric progression of twelve equal steps from our starting number, one, to its double, two. The twelve steps correspond to the ratios of the frequencies of a twelve tone equal scale. Now, to apply this approach to a usable scale, we need a pitch of known frequency to use as a starting point.

WESTERN SCALE

How do we determine a starting point? Basically that has already been established. Orchestras and bands usually tune to the pitch of "A". The letter "A" has been assigned to the frequency of 440Hz. However, in the past, orchestras used to tune to A-435, 438 even as high as 444Hz.

Now, knowing the frequency of the pitch "A", we can apply our mathematical factor. The result will be the next note of the scale. And by continuing the process, we will eventually reach A-880Hz -- one octave above.

(A)	440.00 x 1.0594631 = 466.16	(A#)
	466.16 x 1.0594631 = 493.88	(B)
	493.88 x 1.0594631 = 523.25	(C)
	523.25 x 1.0594631 = 554.36	(C#)
	554.36 x 1.0594631 = 587.33	(D)
	587.33 x 1.0594631 = 622.25	(D#)
	622.25 x 1.0594631 = 659.25	(E)
	659.25 x 1.0594631 = 698.46	(F)
	698.46 x 1.0594631 = 739.98	(F#)
	739.98 x 1.0594631 = 783.99	(G)
	783.99 x 1.0594631 = 830.61	(G#)
	830.61 x 1.0594631 = 880.00	(A)

The same process can be used for going down in pitch by dividing the factor into each frequency.

(A) 440.00/1.0594631 = 415.31 (G#)
415.31/1.0594631 = 391.99 (G)
etc.

Continued dividing will bring 440.00 down to 220.00 -- one octave lower.

NON-TWELVE

Let's take this knowledge and apply it to a different quantity of notes per octave -- say five (called a "pentatonic" scale or five tone equal).

The factor for five is = 1.1486984.

We can use any pitch or frequency as a starting point just as we did with A-440. For example, we'll build a five tone scale on middle C. The pitch of middle C is 261.63Hz (which is derived from A-440 and the twelve tone equal tempered scale).

NON-TWELVE

Let's take this knowledge and apply it to a different quantity of notes per octave -- say five (called an equal pentatonic scale or five tone equal).

The factor for five is $\sqrt[5]{2}$ = 1.1486984.

We can use any pitch or frequency as a starting point just as we did with A-440. For example, we'll build a five tone scale on middle C. The pitch of middle C is 261.63Hz (which is derived from A-440 and the twelve tone equal tempered scale).

(1) 261.63 x 1.1486984 = 300.53 (2)
300.63 x 1.1486984 = 345.22 (3)
345.22 x 1.1486984 = 396.55 (4)
396.55 x 1.1486984 = 455.52 (5)
455.52 x 1.1486984 = 523.25 (1)

NOTE: Sometimes the black keys on the piano are referred to as a pentatonic scale because there are five notes. This is not an equal pentatonic scale because the interval distances vary within the scale.

It is possible to start with any frequency, including ones that have no relation to standard scales. As an example, we'll try 100Hz (a very sharp G).

(1) 100.00 x 1.1486984 = 114.86 (2)
114.86 x 1.1486984 = 131.95 (3)
131.95 x 1.1486984 = 151.59 (4)
151.95 x 1.1486984 = 174.11 (5)
174.11 x 1.1486984 = 200.00 (1)

The twelve tone equal scale has letter names for identification of each note. But on non-twelve scales we assign numbers to designate the steps of the scale.

The interval distance in all equal tempered scales remains consistent throughout. This is what makes modulation from one key to the next possible. The same can be done with 5-tone equal except that the key name might instead be labeled as a number.

TABLE

The following is a list of factors each relating to the quantity of notes within an octave.

QUANTITY	NAME	FACTOR
2	Duotonic (tri-tone)	$\sqrt{2}$=1.4142136
3	Tritonic (augmented)	$\sqrt[3]{2}$=1.2559921
4	Quadritonic (diminished)	$\sqrt[4]{2}$=1.1892071
5	Pentatonic	$\sqrt[5]{2}$=1.1486984
6	Hexatonic (whole-tone)	$\sqrt[6]{2}$=1.122462
7	Septatonic (1/2 augmented)	$\sqrt[7]{2}$=1.1040895
8	Octatonic (1/2 diminished)	$\sqrt[8]{2}$=1.0905077
9	Nonatonic (1/3 augmented)	$\sqrt[9]{2}$=1.0800597
10	Decitonic (1/2 pentatonic)	$\sqrt[10]{2}$=1.0717735
11	Eleven tone	$\sqrt[11]{2}$=1.0650411
12	Twelve tone (chromatic)	$\sqrt[12]{2}$=1.0594631

RECORDINGS

MUSICWORKS 30: SOUND CONSTRUCTIONS

Presents the music of sound sculptures and instruments built by the Logos Foundation, Leif Brush, Richard Raymond, Thaddeus Holownia, Paul Panhuysen and Johan Goedhart.

Published by The Music Gallery; Distributed by Musicworks, 1087 Queen Street West, 4th floor, Toronto, Canada, M6J 1H3. Price, including both the paper and the cassette, is $20/year (4 issues) in Canada, $24 elsewhere. Write for individual issue prices.

Musicworks is Canada's leading new music publication. Each quarterly issue of the journal focuses on a topic of current importance in contemporary music, featuring articles, reviews and scores pertinent to the subject. As part of each issue, subscribers receive a cassette tape through which the journal can talk, sing and play, conveying in sound the substance of the printed pages.

Musicworks 30, dated Winter 1985, bears the title Sound Constructions, and presents the work of several people dealing with various forms of sonic sculpture and sound installations. Samples of the sounds of the installations appearing in the journal are gathered on the Musicworks 30 tape.

Let it be known right away that neither Number Thirty nor the other Musicworks tapes are prepared like a commercial record company's sampler record. John Oswald, who does the mixing and carries the title "cassette editor" for the journal, apparently has made the decision that the integrity of the tape as a whole should override that of the individual pieces. Accordingly, on his tapes he edits freely, mixes material from different sources, and superimposes environmental sounds, recitations and informal talk, all with an ear to creating an aesthetically satisfying whole.

The Sound Constructions tape begins with the work of Godfried Willem-Raes and Moniek Darge of the Logos Foundation of Belgium. First we hear their Pneumafoons. The Pneumafoons are a motley collection of instruments designed to work with irregular and unpredictable fluxes of air from an outside source. Some have whistle-like arrangements, some have single or double reeds, some have

bronx-cheer style double membranes of rubber. Various non-electric means are used to modify the sound after the initial vibration has been set up. These devices are generally enclosed in wooden boxes with "his master's voice" horns protruding. The wind to operate them comes from inflatable plastic cushions. They are filled continuously through air-intake hoses connected to compressors, while outflow hoses lead to the wooden boxes containing the sounding devices. The cushions are just about the right size to sit on or bounce around upon. When the pneumafoons are set up, the cushions are scattered invitingly about the room. Visitors quickly discover that each time they sit down they are involuntarily composing. Sitting down gives way quickly to bouncing, jumping, lolling, punching, and rolling as participants begin to explore the instruments' responses.

The pneumafoons heard on the tape produce a variety of sounds, some with a mechanized, industrial quality to them, but more of them with a distinctly anatomical feel. There are some very full, warm low-frequency sounds, and some reverberant, whale-like sliding pitches. Along with them on the tape we hear the voices of the instruments' builders describing their workings in engagingly unplanned, upbeat conversational exchanges. Their talk is included, I suspect, not for the value of their explanations (which are disjointed, not intended to be definitive), but for the quality of their speech. It is irrepressibly mixed with a thousand vocal sound effects, sometimes difficult to distinguish from the sounds of the instruments carrying on in the background, all part of an antic urge to communicate.

Following the pneumafoons on the tape are excerpts from a performance of a piece by the Logos people entitled "Timeframes." "Timeframes" uses voice and a magnetic-tape-and-playback-heads arrangement in which a prepared tape is drawn over the heads manually by the performer. In addition to being sent to conventional speakers, the resulting signal is sent to a quirky sort of home-made spring reverb system and fed back to the amplifier.

The sounds of a crackle-box follow. Crackle boxes were developed by Peter Beyls and Michael Waisvisz. They are very small, inexpensive, purely-electronic sound generating devices with low-voltage circuitry printed on an exposed board. By touching the circuitry with the fingers in different ways the player creates varying configurations in the electrical connections, resulting in any number of different sounds when the signal is amplified and sent to a speaker. There are sounds of definite (though often sliding) pitch with an electronic pure-sine-wave timbre, mixed in with lots of variations on snap, crackle and pop. A more recent version of the instrument, not heard on this tape, allows for a far greater degree of control and may be tuned, so that the player can produce conventional melodies.

The next segment of the tape turns to the long string installations of Paul Panhuysen and Johan Goedhart, artists living and working in Eindhoven, The Netherlands. These two have produced several site-specific string installations, with strings ranging in length from around fifteen feet to over a hundred. The strings are made of various materials and excited in various ways. Some use electronic amplification and a few use some form of electronic signal processing. The sounds of eight such installations appear on the tape.

The first, christened Victoria, uses an abandoned factory building and strings of twisted steel. The strings run from fastenings on the girders about five stories up to an anchor point on the ground thirty meters away. The structure has no siding in the areas where the strings are attached, and loudspeakers carrying the amplified signal from the strings are placed within the cavernous exposed interior spaces. The insides of the building thus become huge resonating chambers, and the arrangement probably generates some feedback to the vibrating strings as well. The recording of this instrument that appears on the tape is rather lo-fi. In it one hears a chanting voice and a repeating, not-terribly-exciting mid-range tone, with an intermittent squeak from I know not what source.

The remaining seven installations are equally interesting in design and conception. Their sounds are in some cases intriguing, like the peculiar under-waterish sounds of the Pillar Koto. For others, the value of having amplified and recorded them is questionable.

The remainder of side one is devoted to the work of Leif Brush, sound artist from Duluth, Minnesota. Brush has devised ways to gain access to some of the minute events taking place in nature continuously: snowflakes and raindrops on fir needles; the flow of sap in the trunk of a tree; icefloes freezing, and fracturing.

Many of the happenings that Brush monitors are not sounds to begin with. They may be electrical events, such as the small voltage oscillations he has found to occur in living trees, or vibrations occurring in a solid substance which normally would not be transmitted to a "hearable" medium, or variations in pressure or temperature. Through various means he translates these events into oscillations in an electrical circuit within the frequency range of human hearing, so that they can then be run through conventional amplifier and loudspeaker systems. Others among Brush's instruments are designed to capture and transmit actual natural sounds, minute though they may be, in a form as literal, accurate and uncontaminated as possible. A third approach he uses involves the creation of instruments which respond to small natural events -- wind, precipitation, small movements or changing tensions in growing things -- in a biased manner, imposing their own character on the signals they send to the amplifier.

Brush's voice appears here and there throughout his part of the tape. We hear fragmentary comments which, like the words of the Logos people earlier on this side, do not amount to a coherent explanation, but add a counterpoint of thoughts and ideas to the purely sonic surrounding events.

We hear him, in material culled from a radio interview recorded in St. Paul, using a microprocessor to bring in live sounds from some of his Terrain Instruments. The Terrain Instruments are sets of devices arranged around and about a woodland area to monitor natural events. They include wires strung between clusters of trees which respond to the trees' movement, and metal disks which respond to precipitation. Both of these

also pick up other incidental occurrences such as kamikaze insect attacks. Transducers affixed to the wires and disks convert the vibrations associated with these events to electronic signals. The Terrain Instruments also include tubes, membranes and baffles placed in selected locations around the chosen terrain to serve as collection points for sound. There is also a wind ribbon with force, acceleration, vibration and strain-gauge sensors. All of the information from these sensing devices is relayed to an amplifier and then to a remote microprocessor.

Much of the time, as we listen to the Terrain Instruments on the tape, a sweet humming and whining can be heard -- mostly wind? A few moments into the recording a huge, echoing, otherworldly rifle-shot sound comes suddenly, and its reverberations have not died before there is another, and another... this, the liner notes tell us, is the sound of snowflakes hitting one of the sensors. A dancing, dry rhythm interspersed with an occasional echoey sproinnng turns out to be insects "engaged in activity on a trio of wires."

In another project, Brush placed sensors in the ice over Lake Superior and left them there all winter, to capture some of the happenings in that crystal world. The tape immortalizes the sound of one crack which occurred during the winter of 1976. It comes with a mixture of snap and rumble and a sense of rapid travel over great distance.

Brush has gained access to the internal events of trees by boring and implanting a special transducer -- "a pencil-like stainless steel sensor," in his words, "which has pressure gauges and temperature gauges and vibration gauges." The pressure gauges pick up oscillations in voltages within the wood cells associated with changes in sap pressure. The vibration gauges respond to vibrations within the trunk resulting from tensions in the wood, and the temperature gauges pick up changes occurring as external conditions, such as heat from sunlight on the bark, work their way in. All these events are translated into electrical oscillations and sent to the amplifier. The resulting sound -- something like a babbling brook, yet dry and woody -- fits very nicely my unscientific image of the sap flowing.

Musicworks 30 side two bears the name "The Moon and the Wind." The music is an unbroken montage of aeolian instruments, reflecting an article called "Singing Wires: The Music of Aeolian Harps" which appears in the printed portion of the journal. It begins with Richard Raymond's traditional zither-style harp, a rectangular instrument 36 inches long, designed to be placed in an open window to catch the breeze. This harp has a wonderfully clear tone. All the lower partials up to sixth come and go with about equal strength and frequency, while those up to the tenth make occasional appearances. The wind itself can be heard whirling around the window all the while. As Raymond's harp continues to sing, some of Leif Brush's wind instruments are intermittently added to the recording.

Later, the Gigantic Aeolian Harp built by Thaddeus Holownia at Jolicure, New Brunswick, enters the mix. This instrument has eight sixty-foot strings of varying gauges of piano wire. There are wooden structures at each end, both of which have 1" x 12" x 48" pine soundboards without sound boxes. The sound of the big harp is utterly different from that of the smaller. On the Gigantic Aeolian Harp the lower harmonics are subsonic. The harmonics that one does hear are high enough in the overtone series that the familiar intervalic relationships of the lower end of the series no longer apply. The audible pitches are so close to one another and sound so continuously that they lose individual definition. The result is a massive wash of sound, with lots of beating and gradual shifts in the predominant tonal clusters. The tones rise and fall far more slowly in the heavy strings than they do with the small instrument.

The Musicworks 30 tape draws to a close as the sound of the giant harp begins to die away. Over its last strains we hear the voice of Anne Smith reciting "The Moon and the Wind," the poem that gave its name to this side of the tape.

RECENT ARTICLES APPEARING IN OTHER PERIODICALS

Listed below are selected articles of potential interest to readers of Experimental Musical Instruments which have appeared elsewhere in recent months.

"DRAFTING INSTRUMENT PLANS" by Ted Davis, in American Luthierie #4, December 1985 (8222 S Park Ave, Tacoma, WA 98408; $25/yr).

A description of some of the basic tools, techniques and conventions of drafting, applied specifically to the drawing plans for existing guitars but generally applicable to other instruments as well.

"BUILDING THE KAMANCHE" by Nasser Shirazi, in the same issue of American Luthierie (see above).

This article provides plans for the Kamanche, a skin-headed plucked lute of the middle eastern classical music tradition.

"THE PHYSICAL PROPERTIES OF VIOLIN STRINGS" by Norman C. Pickering, in Journal of the Catgut Acoustical Society #44, November 1985 ((112 essex Ave, Montclair, NJ, 07042; $20/yr).

This article provides a detailed comparative acoustical analysis of the vibrating behavior of several makes of violin strings.

ALSO IN THE JOURNAL OF THE CATGUT ACOUSTICAL SOCIETY: Issues of the C.A.S. Journal usually have several highly technical articles on various aspects of violin acoustics, many of which contain more broadly applicable information. In addition, the C.A.S. has a couple of ongoing projects, usually reported on in the journal: members of C.A.S. have been designing and building the VIOLIN OCTET, a family of acoustically advanced violins (at all pitch levels), and they have been researching, practicing and promoting the art of face plate tuning on all the bowed strings.

"PIANO ANIMATION SHADOW PROJECTION PIECE IN TWO PARTS FOR PREHISTORIC EXPANDED CINEMA" (author not credited), in Musicworks 32 (1087 Queen St West, Toronto, Canada, M6J 1H3).

A brief text and several photographs and drawings describe an altered piano, with silhouette cut-outs suspended against or in front of the sounding strings and responding to the vibrations. A light beam directed at and past the strings and cut-outs projects their moving images on a wall.

"THE EVOLVING NATURAL HISTORY OF THE WALL HARP" by Sylvia and Robert Chapman, in Folk Harp Journal #51, December 1985 (31 West Canon Perdido, Santa Barbara, CA 93101; $12/yr).

The wall harp is a heavy wire attached at both ends to the boards of a wooden wall and tuned with a rock bridge wedged underneath. The article gives some brief history and describes further developments of the instrument at the hands of the authors.

"THE SOULCRI WIND HARP" by Ross Barrable, also in FHJ #51 (see above).

This article describes a twelve-foot high wind harp with a concrete foundation and a stainless steel soundboard, built by the author in the shape of a traditional harp.

"THE AXIAL-FLOW VALVE" by O. E. Thayer, in Techni-Com, vol 9 #5, Oct-Nov 1985 (National Association of Professional Band Instrument Repair Technicians, P.O. Box 51, Normal, IL 61761).

A new alternative to the traditional rotary valves and piston valves used on brass instruments is described here. The axial flow valve deflects the direction of the sound wave far less than either traditional valve, allowing for easier playing, greater volume and more centered tone.

"EPO TEK 301" by Phil Duer, in the same issue of Techni-Com (see above).

This article describes and evaluates a new epoxy for use in instrument building and repair.

"WOODWIND KEY REBUILDING" by Edward Kraus, in Techni-Com vol 9 #3, 4 and 5 (see above).

This series provides a detailed nuts-and-bolts account of the workings of the keys for all the orchestral woodwinds.

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To: